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WHAT OF 1934?

The potato industry must give thought to next year. Prices this year have far exceeded expectations at planting time. As the result, the eastern potato grower can pay his bills and has a reserve for planting next year's crop. It is true, however, that the good fortune of the eastern grower came largely from the misfortune of the western growers. Normal growing conditions in the west would probably have resulted in an entirely different price situation.

Other agricultural industries are attempting, with federal aid, to better their position. This is to be accomplished in part by reduced plantings. Will the potato be planted to take the place of some of these crops? Even though this should not prove to be true we must face the fact that a year of high prices has usually been followed by an increased acreage. Already there are indications that this will be the case in the Atlantic seaboard states. With increased plantings and favorable growing conditions the outlook for 1934 is not good.

What is to be done? Are we to proceed as in the past? It is time that we view the potato industry in its natural aspects. It is a short-sighted policy when potato growers in adjoining states ruin themselves and each other through blind adherence to the idea that they can and will run their own business.

Organization is the spirit of the day. We suggest a conference of representatives from the different potato growing sections to discuss steps leading to a stabilized industry. At this time, such matters as acreage and marketing methods should be considered. The growers should have more to say concerning the way the crop they grow is sold. The potato growers should look after their own interests. The need for action is upon us. With the same spirit of cooperation exhibited by other industries it should be possible to place the potato industry on a sound basis.

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THE PHYSICO-CHEMICAL CHANGES PRODUCED BY THE COOKING OF POTATOES

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The culinary quality of potatoes has been a frequent subject for researches both in the United States and in Europe. Results as interpreted have often been contradictory, probably because objective and uniform standards for judging quality have not been developed and because knowledge of the changes which occur during cooking has been incomplete. It is reasonable to predict, however, that the application of the newer physico-chemical concepts and methods of investigation will be as fruitful in rendering the transformations occurring during the cooking of a potato understandable and controllable as it has those in such other foods as cooked cereals and cereal products.

From a physico-chemical standpoint, a potato is a dispersion of starch, sugar, cellulose, protein, ash constituents, and other components in lesser proportions, such as vitamins, solanin, acids, etc., in a water medium. The starch is in suspension, the cellulose and protein in colloidal solution, and the sugar, ash constituents, and most of the other materials in true solution. The physical and chemical changes produced by cooking potatoes are of two types, *i.e.,* those resulting from losses to the cooking medium (for example, minerals and other constituents in true solution in water) or from absorption of the cooking medium (for example, frying fat), and those resulting from the action of heat on the various tuber components. This discussion will be limited to the latter, which, except for a small loss of water by evaporation, includes all of the changes in cooking potatoes by such a method as baking. In this case the effects of cooking are those transformations which heat in a water medium, and hence at temperatures of 100° C. or less, produces in the tuber constituents.

There has been a general misconception of the physical changes developed within a potato during cooking. Atwater (1895) reproduced in a federal bulletin the drawings of a German scientist, Märker, which showed microscopic views of the cells of a raw potato, those of a potato boiled one-half hour, and those of a potato "well-steamed and mashed." According to these illustrations, the cells of

the raw potato appeared to be only partially filled with starch grains. When the potato had been boiled one-half hour, the starch had swollen until it filled, or almost filled, the cells, but the cell walls remained intact. After mashing, the steamed potato presented some broken cells. Although no such conclusion was warranted from these drawings, Atwater himself said "On boiling the starch swells, the cells burst open. . . ." He thus overlooked the fact that the disintegration of the cells may have been due to the mechanical operation of mashing rather than to the cooking process itself.

The words of Atwater rather than the facts as indicated by the drawings have been accepted by most subsequent investigators. Gilmore (1905) thought that mealy potatoes were those containing sufficient starch to rupture the cell walls during boiling. East (1908) also believed that mealiness was due to the presence of sufficient starch to burst the cell walls. In 1917, Langworthy again reproduced the Märker drawings in a federal bulletin but labelled the second "cells of a partially cooked potato," and the third "cells of a thoroughly boiled potato," completely ignoring the fact that the latter had been subjected to mashing. He attributed the bursting of the cell walls to internal steam pressure.

Langworthy evidently had not seen the report of Day (1909) to the effect that her examinations of cooked potatoes revealed no breaking of the cell walls. She wrote "The middle lamella which holds the cells together had dissolved and the cells separated from each other." She had noted Gilmore's statement regarding mealiness and added that her potatoes did not lack that quality.

The experience of the author verifies Day's conclusion. According to microscopic examinations, the starch grains swell during cooking to fill the cells more or less completely and the cells separate more or less readily, but rupturing of the cell walls is not characteristic of cooked potato.

An adequate understanding of the effects of cooking potatoes involves consideration of a number of specific chemical and physical transformations. The most completely studied of these are (1) the gelatinization of starch, (2) the solution of pectic substances, (3) the softening of cellulose, (4) the coagulation of protein, and (5) the caramelization of sugar.

Gelatinization of starch. Starch is present in plant tissue in the form of microscopic granules composed of concentric layers. The outer layer, or envelope, has different properties from the inner bulk of the granule. The former is only very slightly soluble in water and is relatively dense. When heated in water, the envelope starch, which is known as amylopectin, becomes slimy and sticky. The inner portion of the granule, amylose, is readily dispersed either in cold or hot water to form a colloidal solution. It is not known whether amylopec-

tin and amylose are two different chemical compounds or whether their different properties are caused merely by differences in degree of hydration.

When uninjured starch granules are mixed with cold water, a non-viscous suspension is formed, the granules swell but slightly, and gradually settle to the bottom. Heating stimulates swelling, a rapid increase in rate taking place between 50 and 60° C. with a maximum increase in size somewhere below the boiling-point. Alsberg (1926) has estimated that potato starch granules increase 40 times in volume during gelatinization as compared with 8 times for wheat granules. If complete gelatinization is coincident with maximum swelling, it is obvious that the starch present in an average potato in a ratio of 1:6 of water is not completely gelatinized during cooking. This is perhaps indicated by the smaller degree of translucence which develops in a cooked potato as compared with that of potato starch pastes. The temperature of the interior of the tuber at doneness, which varies with tuber size and is about 94° C. in a six-ounce potato cooked by boiling, may or may not be a limiting factor in gelatinization, since the maximum viscosity of 1½ per cent solutions of the starch from some lots of tubers is reached at 92° C. while for others that point is not reached at 98° C. (Dow, unpublished data.)

The solution of pectic substances. The cells of plant tissues are held together by a layer of pectin compounds secreted by the boundary walls and known as the middle lamella. Since this cementing wall is laid down as a double layer it is marked by a median plane of weakness where splitting occurs most readily. Pectins are also laid down as thickenings of the cell walls. There is evidence that the pectins of the middle lamella and those of the cell walls are not identical but both are probably combined with cellulose and, until more is known, the name protopectin may as well be applied to both. Long boiling with water, heating with dilute acids, and the action of an appropriate enzyme change protopectin to the pectin of commerce. Pectin does not possess the cementing properties of protopectin and this change, which is characteristic of natural ripening in fruits, results in softening and the tendency to tissue disintegration. (Appleman and Conrad, 1926.) Ordinary cooking also produces some of this decomposition and the consequent softening and disintegration of the plant substance. (Carré and Horne, 1927.) This change is probably responsible for the ready separation of the cells which characterizes cooked potato as discussed above.

The softening of the cellulose. The cell walls of plant tissue such as that represented by the potato consist of cellulose which is usually reinforced by deposits of hemicellulose. The latter are probably food reserves. On acid hydrolysis cellulose yields glucose only, while the hemicelluloses give other hexoses or pentoses. The hemicelluloses are

soluble in dilute base but are mostly insoluble in water, though one has been reported which is completely extractable from wood in hot water. (Haas and Hill, 1929–9.) It is not known just what change cooking produces in the hemicelluloses in ordinary foods but D'Ippolito (1928) suggests that excessive deposits of hemicellulose along with excess cellulose prevent hydrolysis of the pectins and delay cooking.

Cellulose is so resistant to most chemical action that little decomposition is expected during cooking of foods. However, some change must occur because cooked cellulose is subject to more digestive action than is the uncooked. When the fibrous material from washed grated potato pulp was fed to rats raw, the amount of crude fiber recovered in the feces was considerably greater than when it was fed after being heated (Woodruff and Miller, 1929).

Coagulation of the protein. The protein of potatoes consists largely of the globulin tuberin. The globulins are a group of simple proteins which are insoluble in pure water but soluble in dilute neutral solutions of the salts of strong acids and bases. Due to this property, most of the potato protein is in solution in the juice. On heating, tuberin coagulates gradually over a range of temperatures which varies with the condition of its solution, but the coagulation is complete at 80° C. (Osborne and Campbell, 1896.) Thus the interior temperature of a potato when it is thoroughly cooked is always such that most of the protein is completely coagulated.

Caramelization of sugar. Potatoes contain amounts of sugar varying from almost none to over five per cent, the quantity depending upon the conditions of storage. (Sweetman, 1931.) It is well known that sugar undergoes a change called caramelization during heating. This process may begin at temperatures less than boiling if moisture is present. Caramel is not a substance of definite composition but a mixture of ketones, aldehydes, and other compounds with shorter carbon chains than that of the monosaccharide molecule. Caramelization is manifested by the development of a brown color and is observable in potatoes especially when they are French-fried or made into potato chips. Even baked potatoes may develop a creamy tint when their sugar content is high. Caramelization of excessive amounts of sugar in potatoes may produce not only an objectionably dark color but also an alteration in flavor which may be very unpalatable.

Other changes. Constituents present in potatoes in smaller proportions than those discussed are doubtless factors in cooking quality. For example, Tinkler (1931) has concluded that the darkening which takes place in certain cooked tubers upon standing is due to an oxidation, perhaps of a phenol or an amine. It is entirely possible that other important cooking qualities, such as mealiness, may be influenced by effects of less prominent components, but these are as yet not known.

SUMMARY

Cooking of potatoes does not cause the bursting of cell walls but permits ready mechanical disintegration of the tuber tissue by separation of cells. The process is characterized by such physico-chemical changes as partial gelatinization of the starch, the solution of some of the pectic substances, the increased digestibility of the cellulose, the coagulation of most of the protein, and more or less caramelization of the sugar. Probably constituents present in smaller proportions are also important in their effects on culinary quality.

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CAUSES AND PREVENTION OF POTATO TUBER DEFECTS AT HARVEST TIME

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Potato harvest will soon begin again in the northern late potato states. Government forecasts indicate a short crop and higher prices

than were obtained last year. Growers will do well to safeguard both yield and market quality of this year's crop. Much that is invested in good seed, seed treatment, and spraying to reduce losses from diseases and insects is lost every year through careless methods of digging and handling at harvest time. Most growers fail to observe or to appreciate the great amount of mechanical injury done and the losses sustained in the actual digging process. A field survey made in New York at harvest time on 101 farms in 1931 and on 137 farms in 1932 showed that on the average over 20 per cent of the tubers as dug are affected with either mechanical injury or physiological defects. A summary for the two years is given in table 1.

TABLE 1.—*Mechanical and physiological defects in potato tubers on 238 New York farms in 1931 and 1932*

Defect	1931—101 Farms		1932—137 Farms		Average 1931–1932 per cent
	Average per cent	Range per cent	Average per cent	Range per cent	
Digger bruised	6.8	0–48	11.1	0–42	9.0
Digger cut	2.3	0–13	1.5	0–15	1.9
Skinned	2.8	0–21	2.0	0–21	2.4
Sunburned	5.6	0–31	4.1	0–22	4.9
Second growth	0.5	0–4	1.0	0–9	0.8
Misshaped	1.7	0–11	1.9	0–9	1.8
Growth cracked	0.9	0–8	0.7	0–5	0.8
Sound tubers	79.3	32–98	77.8	50–99	78.6

This study shows that on the average about 9 per cent of the tubers are bruised while an additional 4.3 per cent are skinned and cut by the digger. Such injury not only detracts from the appearance of our potatoes in the markets but also the grower or buyer who stores the crop sustains a subsequent loss from shrinkage and decay. Doctor Ora Smith in recent potato storage studies at Cornell University compared the storage loss from carefully harvested potatoes with that from tubers handled in the ordinary way. Over a seven-months' period, mature potatoes carefully handled shrunk 5.5 per cent in weight while those containing the average number of bruised and cut tubers lost 8.5 per cent. Similarly, immature potatoes shrunk 8.1 and 11.7 per cent respectively. In other words, immature tubers with their thin skins will shrink an average of 3 per cent more from water loss and decay than will mature potatoes held over the full storage period. Also careful handling at harvest time will save an average of about 3 per cent in storage shrinkage as compared to ordinary handling.

Maturity Related to Bruising and Skinning

A crop harvested before complete maturity should be handled more carefully than one normally matured. It is much more subject to bruising and skinning. This is evident from the data shown in table 2.

TABLE 2.—*Relation of maturity to per cent of tubers bruised and skinned*

Condition	1931			1932		
	No. of samples	Bruised per cent	Skinned per cent	No. of samples	Bruised per cent	Skinned per cent
Mature	78	9.04	2.90	77	8.81	3.26
Immature	31	9.52	11.07	30	14.30	9.47

Digger Operation and Equipment

Many different makes of machine diggers are now used throughout the United States. Thirteen types were found in operation on 161 farms in 15 counties of New York last fall. Most of these are of the chain elevator type and all of them appeared to be capable of efficient work if properly operated and equipped. Wherever the digger was found to cause much injury to the tubers, the fault could have been largely remedied. Most of the bruising was due to too harsh contact of the tubers with the elevator chain rods. This was especially true where the soil was dry and only a little was carried over the elevator. Diggers rigged with a continuous chain usually cause less injury than those carrying rear attachments. Apparently the drop of 10 to 15 inches from the front elevator onto either the rear elevator or shaker bars adds some bruising. This is evident from the field studies made in both 1931 and 1932 as shown in table 3.

TABLE 3.—*Relation of digger equipment to bruising of tubers*

Digger equipment	1931		1932	
	No. of fields	Bruised tubers per cent	No. of fields	Bruised tubers per cent
Continuous apron	13	3.77	23	7.52
Extension elevator	80	5.93	54	12.50
Rear shaker bars			67	10.39
Boss or reel digger	10	9.20	4	15.25

Many growers will say at first thought that the amount of injury done is unavoidable because of the construction of the digger and conditions prevailing at harvest time. But most diggers can be adjusted

and operated to avoid much of the difficulty. Where very little soil is carried as is true in a dry time, the speed of the chain should be reduced by a simple change of gears or by throttling the engine in the case of engine-mounted diggers. The eccentric agitators under the front chain may be replaced with rollers. Although padding is probably not necessary in most cases, it should be done to protect tubers from sharp points of contact found to be responsible for bruising. Where separation is easy and the ground is free from sharp stones, the rear attachment of the digger may very well be removed entirely. Similarly the vine kickers which sometimes cause injury should be eliminated. That the amount of soil carried by the digger chain has a direct bearing on mechanical injury is evident from the data shown in table 4.

TABLE 4.—*Relation of amount of soil carried by digger chain to tuber bruising on 72 New York farms in 1932*

Proportion of digger elevator covered with soil (per cent)	Number of farms	Average drop to rear attachment (inches)	Tubers bruised (per cent)
25 or less	19	12.5	13.8
33 to 50	12	12.4	8.4
75 to 100	41	12.0	5.7
Average and totals	72	12.2	8.3

Finally, care in the method of picking up the freshly dug tubers may save considerable loss from bruising. Although about 50 per cent of New York growers pick directly into bushel slatted crates, splint baskets, wire stave baskets and tin pails are coming into more common use. A comparison on 247 farms of the amount of tuber injury resulting where each of these containers was used clearly showed that the slatted crate is the worst offender. Where crates are used, the tendency is to throw the tubers farther than where baskets or pails are used. The additional handling necessitated where baskets were used by pouring into crates or bags did not add materially to the total amount of injury found.

DESIRABLE METHODS OF HANDLING AND STORING POTATOES

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Before accurate information concerning the storage of potatoes can be given it appears necessary to determine the conditions existing

within the mass of tubers. This involves temperature, humidity, evaporating power of the air, and the composition and movement of the air within the bins.

Data obtained of the storage-room atmosphere surrounding the bin or pile of potatoes do not accurately show the true environmental conditions. Results of potato-storage experiments in which small lots of tubers have been stored may be of little value in solving the problems in the storage house where they are usually stored in bulk. The environment of the bulk of the potatoes in a bin, for instance those not exposed to the open air, is vastly different from that on the top surface of the bin. A small lot of tubers exposed to the air on all sides or enclosed in small containers will have an entirely different environment and, therefore, will not react the same as those stored in a large bin in bulk.

The Smooth Rural variety was used in these experiments which were conducted at Cornell University. Several years' results are available but for the sake of brevity only those of the 1931–32 storage season will be given here.

A total of 32 lots of 600 pounds each were stored in one large bin. Each lot was separated from the other lots by one-inch mesh wire netting nailed onto wooden frames. Each compartment, which held 10 bushels, was 3 feet long, 1 foot wide, and 5 feet deep. Bunkers at each end also were filled with potatoes so that the experimental lots were exposed only on top. The bin was 18 feet long, 6 feet wide and 5 feet deep.

EFFECT OF PRESTORAGE TEMPERATURE AND HUMIDITY ON SHRINKAGE AND DECAY LOSSES DURING SUBSEQUENT STORAGE

Immediately after being harvested, potatoes, even if not injured, lose weight at a greater rate than during any subsequent period during dormancy, because of more rapid evaporation from the surface and more rapid respiration. At the time of harvest, the periderm layer of the tuber is only partly formed; the process continues for some time depending upon the environmental conditions. It is now well known that the temperature and humidity to which the potatoes are subjected will govern the rate at which this protective periderm layer will be formed over the wounded areas. Temperatures under 70° F. and relative humidities lower than 95 per cent tend to slow up this process. It is desirable to hasten wound-periderm formation in order to reduce the loss in weight by increased respiration and evaporation from the wounded areas or from the uninjured portions on which periderm formation is only partly complete. In many cases the most serious loss resulting from mechanical injuries is the rotting caused by various fungi and bacteria which gain entrance to the potato largely through these injuries. If the injury heals quickly and completely, the entrance of these organisms may be prevented.

TABLE 1.—*Influence of Prestorage Temperature and Humidity on the Loss in Weight and Decay of Potatoes During Storage, 1931–32*

Prestorage treatment	Loss in weight (per cent)											
	1-month storage			3-months storage			5-months storage			7-months storage		
	Shrinkage	Decay	Total	Shrinkage	Decay	Total	Shrinkage	Decay	Total	Shrinkage	Decay	Total
					Immature tubers							
High temperature, high humidity, 11 days	2.41	1.16	3.57	3.31	1.54	4.85	4.62	1.67	6.29	6.08	2.41	8.49
Low temperature, high humidity, 11 days	2.92	1.60	4.52	3.95	3.08	7.03	5.41	3.50	8.91	7.24	4.04	11.28
					Mature tubers							
High temperature, high humidity, 12 days	2.08	0.25	2.33	3.04	0.64	3.68	4.20	1.43	5.63	5.08	1.50	6.58
Low temperature, high humidity, 12 days	2.37	1.16	3.53	3.45	1.50	4.95	4.41	1.75	6.16	5.41	1.95	7.36

This portion of the study was conducted to determine the effects of storage temperature of the potatoes for a brief period immediately after harvest on their shrinkage and rot loss in subsequent storage. Immature and mature tubers were harvested 14 days apart in October, 1931. One half of each lot was carefully harvested and the remaining half harvested in the normal manner as described later in this paper. On each harvest date one-half of each of the above four lots was placed at a temperature of 45°–46° F. for 11 to 12 days and the remaining half placed in a warm room at 65° to 68° F. for the same length of time. At the end of the preliminary storage period all lots of tubers were placed in the same permanent storage. Continuous temperature and humidity records were obtained and the evaporating power of the air was measured with a standardized white spherical atmometer during the permanent storage period. Each figure in table 1 represents the average percentage loss from two 10-bushel lots of tubers stored in the large bin.

The data indicate the importance of the storage temperature and humidity for a brief period immediately after harvesting the potatoes. Tubers stored at the higher temperature lost considerably less weight during subsequent storage than those stored for the same length of time at a lower temperature but approximately the same relative humidity. The lower prestorage temperature retards the process of suberization and wound-periderm formation, therefore the period of rapid loss by evaporation and the high rate of respiration is prolonged. This results in a greater loss in weight from those stored at the lower temperature.

Some organisms which cause tuber decay in storage are unable to penetrate the unbroken skin of the tuber. Bruised, skinned and cut potatoes, unless the injured surfaces are quickly healed, offer little resistance to the entrance of these organisms and serious decay often results. It has been shown that when fully formed, the wound periderm excludes all species of Fusarium yet tested as effectively as the normal uninjured periderm. The lots subjected to the high temperature immediately after harvest had fewer decayed tubers than those stored at the lower temperature just after harvest. The greatest amount of rot occurred in the normally handled tubers which had been subjected to the low prestorage temperature. This was followed in the order of decreasing amount of decay by the (1) normally handled, lower temperature, and (3) carefully handled, higher temperature lots. Therefore, two factors which reduce the amount of decay in tubers are: (1) careful harvesting and handling methods which reduce wound injuries and (2) placing the newly harvested tubers under conditions of relatively high temperature and humidity for a brief period in order to hasten wound periderm formation. It has been shown that at temperatures below 50° F., even at a favorable humidity, the tubers

are not able to form, within 10 days, a protective layer over or beneath wounds that excludes the more virulent rot organisms.

EFFECTS OF MECHANICAL INJURIES IN HARVESTING ON THE LOSS IN WEIGHT AND DECAY OF POTATOES

Until recently very little attention has been given to the amount of mechanical injuries of tubers caused by the digging, handling and storing operations. Little information is available regarding the activity of normally injured tubers during the subsequent storage period.

In order to compare the carefully handled with the normally handled potatoes the potato digger and the picking baskets were padded for one-half of the harvest and the tubers harvested in this manner designated as "carefully handled." Those designated "normally handled" were harvested with the same digger unpadded and picked up in the same containers from which the padding had been removed.

In every case, the carefully harvested and handled tubers show a smaller percentage of loss in weight and decay than those harvested and handled in the normal manner. This is true with the immature as well as the mature tubers at the end of each of the one-, three-, five-, and seven-months' storage periods. The average percentage loss in weight and decay of all carefully handled lots was 4.52 as compared with 7.36 for those with normal handling.

Mechanical injuries result in losses other than those which are very obvious when preparing injured potatoes for table use. Immediately after being injured, potatoes lose weight unusually fast because of more rapid evaporation from the injured surface and more rapid respiration. As the wounded surfaces heal, weight losses from both of these causes decrease until they are no greater than from uninjured potatoes.

Potatoes were stored for periods of 1, 3, 5 and 7 months. In almost every case, the potatoes lost the least weight during the second and third and the fourth and fifth months of storage. A greater loss occurs during the first month of storage than for any subsequent equal period of time. However, when extensive sprout growth occurred in the spring during the sixth and seventh months of storage, losses in weight again increase very rapidly. This again indicates that after the wounds have been healed and the permanent thick periderm has been formed over the freshly harvested tubers that loss in moisture is very slow until evaporation again is increased through the sprouts late in the storage season.

Results of analyses of air withdrawn from various portions and depths of bins of potatoes throughout the storage period in several types of potato storage cellars showed that at no time was there a low

TABLE 2.—*Influence of Manner of Harvesting and Handling Potatoes on Loss in Weight and Decay During Storage, 1931–32*

Treatment	Loss in weight (per cent)											
	1-month storage			3-months storage			5-months storage			7-months storage		
	Shrinkage	Decay	Total	Shrinkage	Decay	Total	Shrinkage	Decay	Total	Shrinkage	Decay	Total
					Immature tubers							
Carefully handled	2.12	0.93	3.05	2.91	1.66	4.57	3.58	2.08	5.66	5.87	2.20	8.07
Normally handled	3.21	1.83	5.04	4.35	2.95	7.30	6.45	3.08	9.53	7.45	4.25	11.70
					Mature tubers							
Carefully handled	1.79	0.29	2.08	2.25	0.66	2.91	3.14	1.23	4.37	4.33	1.16	5.49
Normally handled	2.66	1.12	3.78	4.24	1.46	5.70	5.47	1.95	7.42	6.16	2.29	8.45

supply of oxygen or a harmful supply of carbon dioxide in the air. These results indicate that where the temperature of the air in the storage is not excessively high for good storage of potatoes the ventilation for the specific purpose of replenishing the air to increase the oxygen or to decrease the carbon dioxide percentage is unnecessary. In fact, overventilation may, and often does, increase the losses in weight of the potatoes because of excessive drying out of the air. Studies at Ithaca concerning the differences in loss in weight of tubers stored in an insulated and an uninsulated cellar and in slatted and solid-sided bins showed that slightly larger losses occurred in the slatted bins due, no doubt, to excessive drying out of the layers of potatoes exposed to the open air.

In most of these storage studies a positive relation is shown between low shrinkage losses of potatoes and high average relative humidity, low average temperature, and low evaporating power of the air surrounding the bin. However, further results have shown that if the tubers are carefully dug and then subjected for a week or two to storage conditions conducive to rapid periderm formation, that up until the time that sprouting occurs, there will be little difference in loss of weight of these potatoes regardless of temperature and humidity conditions during the permanent storage.

Two groups of factors are involved in potato storage: *First,* the condition of the crop itself, and *second,* the conditions within the storage house. The most efficient storage will not convert badly bruised, skinned, cut, diseased, frosted or otherwise unsound tubers into marketable grade. For this reason it is imperative that careful harvesting precede the storage of potatoes. In this sense, the storage period begins with the harvesting of the crop.

RECOMMENDATIONS FOR STORAGE MANAGEMENT

(1) Do not harvest potatoes until they are mature.
(2) If possible, dig when the soil is slightly moist, thereby reducing tuber injury from the digger.
(3) Operate the digger deep enough to avoid cutting the tubers.
(4) Pad all parts of the digger that are likely to bruise or skin the potatoes, or adjust digger to minimize tuber injury.
(5) Pad all picking containers or use containers with rounded, rather than sharp edges and corners.
(6) Do not drop or throw potatoes unnecessarily or walk on them when loading or unloading.
(7) Do not place freshly harvested potatoes in cold storage or at temperatures below 50° F. until a week or two after harvest. Keep them where it is comparatively warm and moist for the first few weeks.
(8) During the storage period try to keep the temperature of the potatoes between 36° and 40° F. Since the temperature

within a large bin of potatoes is 2 to 5 degrees higher than the air surrounding the bin, the above air temperatures may be lowered several degrees for best results.

(9) Try to maintain the relative humidity of the air between 85 and 95 per cent, that is, just below saturation so that no moisture condenses and drips from the walls and ceiling or collects on the top layer of potatoes. If the temperature is kept low, usually no harm results even though the top layer of potatoes is completely moist. However, with temperatures above 40° F. molds may develop at any time and sprout growth be extensive early in the spring.

(10) Use ventilation only as a means of controlling temperature and humidity. There should be a good thermometer and if possible a hygrometer or psychrometer for measuring the amount of moisture in the air of the storage house.

SECTIONAL NOTES

MAINE

Our growers have been considerably heartened by the Government reports of July and August. The conditions are looking more favorable for every one in the deal than has been true for some time.

While there has been a noticeable improvement over conditions existing a month ago, the weather is holding very dry. The heavy showers that we have had, while giving us a normal total amount of rainfall, have come with such intensity that much was lost by running off. The streams and rivers are very low, lower than usual at this time of the year.

It has been the experience in Maine that years of dry weather have given us crops of fine quality and good average yield, so that we are not unduly alarmed over yield prospects. The set on the plants seem to be heavier than the average. Whether there will be enough moisture to develop all of the tubers that have been set remains an open question.

We have been very fortunate this season in having no appreciable amount of blight develop thus far. Scattering leaves of blight have been found in each community but the weather has been such that it has not spread to any extent. Then, too, the growers after the previous three years' experience are "on their toes" more than usual to take any steps necessary to control it. Everyone realizes the great importance of producing every barrel possible and is watching his crop closely.

Much interest has been shown lately in the developments in the produce trade in relation to the National Industrial Recovery Act. There is a feeling on the part of many experienced growers and shippers that it is an admirable time to bring about some sorely needed

reforms in the produce trade. Any sound, constructive program will receive a great deal of support from Maine. These reforms can only be brought about by the growers and shippers themselves, seeking to secure justice in the competitive market for the producer.—FRANK W. HUSSEY.

KANSAS

Potatoes are produced in every section of the state and are grown in almost every home garden. The principal commercial producing section is the Kaw Valley. This section extends from Kansas City, to Rossville, and includes the counties of Wyandotte, Johnson, Leavenworth, Douglas, Jefferson and Shawnee. This section, at present, grows from 12,000 to 15,000 acres of potatoes annually and usually ships from 3,000 to 4,000 cars. Scott County, in western Kansas, grows from 800 to 1,000 acres annually under irrigation. Reno, Sedgwick, and Cowley Counties produce some potatoes on a commercial scale but supply very few car-lot shipments to distant points.

The potato crop is one of the few crops in the state that shows substantial increases in yield per acre over what was produced 15 and 20 years ago. This is especially true in the Kaw Valley. In this territory, a comparison of the yields per acre over 5-year periods since 1910, as reported in the biennial reports of the Kansas State Board of Agriculture, shows rapid improvements in production. Yields for these periods are as follows:

5-year Period	Average Yield in Bushels per Acre
1910–1914	80
1915–1919	99
1920–1924	115
1925–1929	150

This increase in yield has been accompanied by a very material improvement in quality, resulting from improved production practices and proper grading and marketing methods.

During the past 14 years, seed treatment has increased yields an average of 33 bushels per acre, and the use of certified seed has increased yields from 35 to 40 bushels per acre. Other improved practices have added their share to better yields. Most of these practices are now followed by from 75 to 80 per cent of the commercial producers and by a large number of home gardeners.

Previous to 1920, the Early Ohio was the principal variety of potato grown. Since that time the Irish Cobbler variety has been introduced and now constitutes about 95 per cent of the commercial crop. At the present time, research workers are endeavoring to find

a new variety of potato that is more satisfactory than those now being grown. This year, through the cooperation of Dr. F. J. Stevenson, of the U. S. Department of Agriculture, and Dr. F. A. Krantz, of the Minnesota Agricultural Experiment Station, the research specialists of the Kansas State College are experimenting with eleven new seedling varieties. The more promising seedlings will be selected from this number and given further trial.

During recent years, the potato 4–H Club Project has received much attention. In 1926, only 10 potato 4–H Club members were enrolled in Kansas. In 1932, this number had increased to 397, and this year a membership of 500 is anticipated.

Two other activities that have been of great benefit to our commercial producers have been the adoption of shipping point inspection service and the organization of the Kaw Valley Potato Growers Association, a cooperative marketing organization. The shipping point inspection service has been in use for the past eight years. Since its adoption, Kaw Valley potatoes have been moving direct to consuming centers, instead of being consigned to Chicago. As a result, Kaw Valley potatoes are being shipped to many consuming centers that were never reached previous to the adoption of the inspection service.

Another aid to the potato growers of the state has been the establishment of a potato experimental farm in Jefferson County. This farm was established in 1932 and is under the direct supervision of the Kansas Agricultural Experiment Station staff at the Kansas State College, Manhattan, Kansas.—E. H. LEKER.

NEBRASKA

In the case of the early potatoes, grown without irrigation, in the eastern and southern part of the state, the excessively hot weather in June prevented tuber development and almost killed the vines. A series of fairly general rains during the last week in June accompanied by somewhat lower temperatures, revived the vine growth, but tuber production was at a standstill for 3 or 4 weeks. A number of small, new tubers were found on the plants the latter part of July, but most of the increase in tuber weight seemed to be occurring in the larger tubers. As a consequence, by the middle of August, with vines still green, a great deal of tuber growth was in the form of second growth and the market quality of the crop will be very poor. The Early Ohios seem to show second growth although the Irish Cobblers have almost as much. The Triumph plants have held up surprisingly well and the tubers are not as rough as are those of other varieties.

Where the early potato crop was irrigated, as was the case in the Platte Valley, the yields are good and although the market quality is not what it might be, it is a great deal better than in the unirrigated regions.

In the northwestern part of the state, where the Triumph variety predominates as a late crop, there is quite a contrasting set of conditions. Rainfall during the middle of May, amounting to about 8 inches, provided excellent conditions for the plantings made during the early part of June. These plantings are showing up with excellent vine growth and practically a perfect stand. About the 15th of June there was a pronounced increase in temperature. The maximum air temperature between June 16 and July 5 was 88 degrees or above every day, in the vicinity of Alliance. This excessive heat, accompanied by considerable wind, resulted in the drying out of the upper several inches of soil. This soil moisture condition was responsible for increasingly poorer stands of potaotes, with successive plantings made during the last two weeks in June. In experimental plots and in commercial fields, best results were secured following deep plowing, where the potatoes were planted with a high ridge over the row, or where the soil was compacted with a roller either before or after planting. Fall plowing was not as satisfactory as spring plowing. Late spring plowing resulted in almost a complete failure to secure a stand. In many instances, where seed pieces were properly healed before planting, most of them were still found intact 60 days after planting, having produced sprouts from one to four inches in length. On these sprouts there was very little root growth, probably none having occurred prior to rains, which fell about August 10.

In the irrigated sections, best stands were secured in late plantings when the soil was irrigated thoroughly before plowing. The next most desirable procedure was to apply water in the furrows immediately before planting. This was slightly better than irrigating after the potatoes had been planted. Any of these methods, however, was far superior to planting potatoes late without irrigation.

With regard to diseases, the virus situation is vastly different from what it was some years ago. Probably 90 per cent of the certified seed potato growers are using stocks which trace back to potatoes that were tuber indexed by the Agricultural College sometime during the last 6 years. Probably ⅓ or more of the growers are using indexed stocks which trace back to individual tubers. All of these stocks are relatively free from mosaic and spindle tuber. The tuber line lots are in special favor because of the very general uniformity of the plants.

Fusarium eumartii and *Fusarium oxysporum* appear to be quite prevalent in most of the counties, being much more severe in the early than in the later plantings.—H. O. Werner.

CONNECTICUT

According to the Crop Reporting Service of the United States Department of Agriculture, Connecticut and Massachusetts each have 1,000 more acres of potatoes in 1933 than in 1932. The two states are estimated to have a total of 27,000 acres devoted to this crop this year.

It is my opinion that most of the increased acreage in potatoes is on land formerly planted with tobacco. Most of these former tobacco fields are very well adapted to potatoes. They are relatively level and have easily tilled, sandy loam soil that has been fertilized liberally for a long time. In fact, given reasonable rainfall, these old tobacco fields will produce 250 or more bushels of potatoes per acre for two or three years without any fertilizer.

For several years there has been a gradual shift in potato growing from the dairy and general purpose farms to the more suitable, specialized crop farms in the Valley. Of course, this is partly due to the greater efficiency with which a grower who can afford to have the most modern machinery, is able to raise potatoes. However, I believe this year there is a considerably larger acreage in home gardens and in one- or two-acre patches on farms than in any year since 1920.

Since potato-growing in Connecticut has become concentrated chiefly within a radius of twenty miles from Hartford, marketing the crop in that city soon after digging, as was formerly the custom, has become impractical. Several of the larger growers have built storage houses or have renovated tobacco sheds or barns for holding their potatoes throughout the winter months. There are a few men each with storage facilities for 50,000 bushels. However, many more storage houses are needed if the marketing is to be done in an orderly manner.

Undoubtedly, the extremely dry weather from June 18 to August 19 has decreased greatly the yields of potatoes in the Connecticut Valley. Many fields of Green Mountains on the more sandy soils were prematuring on July 22. The government estimates, released August 12, gave Massachusetts and Connecticut an increase of 185,000 bushels over 1932, but it seems doubtful if the crop will be that large. Most farmers are reporting a light set and a large percentage of small potatoes. The recent heavy rains came too late to offset the previous dry weather damage. Moreover, the existing high prices are tempting some farmers to dig their potatoes before the vines are entirely dead and this will reduce the crop further.—B. A. Brown.

PRINCE EDWARD ISLAND

The Seed Potato situation in Prince Edward Island is a rather complex one this year. At time of writing, August 19th, we are having the first real downpour of rain for a matter of six or seven weeks, breaking what has been the worst drought in many years. Our average rainfall for the month of July for the past thirty-two years is 2.95 inches, whereas this year it was only .63 of an inch, and that only in showers which did not penetrate to the roots.

As a consequence of this rather abnormal condition, plant growth was seriously retarded during the period when it should have been

at its best. However, there were several compensating factors that materially assisted in keeping the vines from suffering too greatly from the lack of moisture. These are, first, the fact that the growers seemed to realize the need of thorough spraying with Bordeaux mixture. Second, the almost complete absence of "Flea beetles" which frequently cause more harm than they are given credit for. Third, the freedom in practically all fields of any "Aphids" which would most assuredly have caused considerable injury had they been present. Fourth, a great many growers, in an endeavor to reduce their cost of production, used barnyard manure and smaller applications of chemical fertilizers. The manure had the tendency to hold the much needed moisture whereas chemicals alone were frequently found undissolved and of no benefit to the plants. Fifth, the temperature during this dry spell was not abnormally high, in fact it was slightly less than the average for the period. Mean temperatures for June and July over a period of twenty-one years to 1932, were 58.87° F. and 65.3° F., respectively, and for 1933, 58.82° and 65.3° F. Consequently, very little wilting of the plants took place during the drought, indicating considerable inherent vigor.

In spite of these various influences, the crop has undoubtedly suffered to a certain extent. Fields that were planted in late May and early June, our best average planting dates, stood up remarkably well, having made good root and vine growth when moisture was available. These plants are now showing a fair set of four or five tubers, and although as yet small in size, they should make a very fair crop. On the other hand, the later plantings, June 15th to 25th, got away to a rather poor start and consequently remained more or less at a standstill for the period of the drought. These fields will now recover somewhat, depending on the type of soil and fertilizer application. These late plantings have made only a light set of about three tubers and they are quite small. The yield will likely be low, but may increase considerably with favorable weather from this date on.

Acreages entered for inspection this year were materially reduced except in the case of Cobblers as shown in the following table:

TABLE 1

	I.C.	G.M.	O.V.	Per cent total acreage passing final inspection
1931, Entered	12,005	12,263	626	
1931, Passed	10,926	10,284	567	87.5
1932, Entered	7,582	8,695	468	
1932, Passed	6,708	5,850	406	77.4
1933, Entered	7,800	6,274	197	

The average per cent disease present in all fields passing final field inspection for the past two years is shown in Table 2.

TABLE 2

	Black Leg	Leaf Roll	Mosaic
1931	0.023	0.006	0.087
1932	0.035	0.003	0.101

This year we are finding scarcely any Black leg, in fact, even less than last year. Our growers still use the recommended seed treatment, bichloride of mercury 1 : 1,000 dip for 1½ hours.

Leaf roll, as shown by the above table, is found in negligible quantities and very frequently is not present in a great many of our fields.

Mosaic is still the bane of all our Green Mountain growers, and, with the exception of those planting their crop by the tuber unit method, is the greatest seed-borne disease factor to be considered in the production of certified Mountains. Our Cobblers are relatively free of this disease.

We have not as yet included Spindle Tuber in our percentages for the simple reason that we have not found it either in sufficient quantity or frequent enough to classify it with the other virus diseases. It is present, but only in isolated fields. The writer knows of only three fields in which it has been found this year, and we are making strenuous efforts to keep it at an absolute minimum and hope we may eventually eliminate it entirely.

Present indications, therefore, point to the probable production of a short crop of certified seed in this Province, the smallest for a number of years. The average will not likely exceed 150 bushels per acre, although that may increase with more favorable conditions as the season advances. Harvesting will not commence until September 20–October 1st, so the Cobblers have at least a full month to grow from date of writing, and longer still for the Mountains.

There should be a considerable quantity of certified small sized seed available this year. This grade calls for tubers ranging from 1½ to 3 ounces in weight and coming from fields which are relatively free from virus diseases makes excellent seed stock, particularly where used for commercial production.—S. G. Peppin.

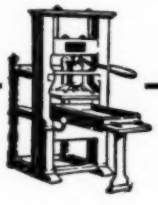
NEW JERSEY

The local growers have had one of the most successful seasons for years. The average yield was fair and the price excellent. A majority of the growers attribute the successful year to be due in great part to the marketing organization through which the crop was sold. Approximately 4,500 cars of potatoes were sold through the Potato Sales

Company, which was made up of a majority of the Central Jersey dealers. The total volume of business done through the office was slightly less than three million dollars.

Various estimates have been made of the increased returns to the growers as the result of this organization. While there is no accord on this point, all agree that it was very much worth while in that it did away with the price cutting and special deals so prevalent under the old system of marketing. The results have been so outstanding that plans are already under way for a similar organization next year. It is hoped that every dealer and grower will sign up for the 1934 crop and, as a consequence, the organization should be even more successful than it was this year. There is some indication also that the Long Island growers may be interested in a similar organization another year.

The New Jersey growers are convinced that they have made a step in the direction of a stabilized industry, they are convinced that it would be a serious mistake to return to the former method of selling the crop where the producer has little or nothing to say concerning the way his crop is to be sold. They believe that, through cooperative effort on the part of the growers and dealers they have found a solution to one of their most perplexing problems.—Wm. H. Martin.



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